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BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL
MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION

RESEARCH REPORT

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REPORT NO. 2
REVISED

BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA (●EFFECTS') AND CLINICAL
MANIFESTATIONS ATTRIBUTED TO HICROWAVE AND RADIO-FREQUENCY RADIATION

Zorach R. Glaser, Ph.D.
LT, MSC, USNR

Research Report

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ABSTRACT

More then 2000 references on the biological responses to radio frequency and microwave radiation, published up to June 1971, are included in the bibliography.* Particular attention has been paid to the effects on man of non–ionizing radiation at these frequencies.

The citations are arranged alphabetically by author, and contain as much information as possible so as to assure effective retrieva o the original documents. An outline of the effects which have been attributed to radio frequency and microwave radiation is also part ot

the report.

♦Three supplementary listings bring the number of citations to more than 2300.

Key Words

Biological Effects
Non-Ionizing Radiation
Radar Hazards
Radio Frequency Radiation
Microwave Radiation
Health Hazards
Bibliography

Electromagnetic Radiation Injury

The comments upon and criticisms of the literature made in this report, and the recommendations and inferences suggested, are those ot t author! and do not necessarily reflect the views of the Navy Department

or of the Naval Service.

Security Classification

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BIBLIOGRAPHY of i,sported biological PHENOMENA ('EFFECTS') and clinical
MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION

a. oescAiPtivE NOTES (Type of report and inclusive dmt**)

Medical research interim report, bibliographic (Current to April 1972)

Z AuThORISi (Fttit name, middle initial, la »t name)

Zorach R. GLASER , Ph.D.

LT, MSC, USN

distribution statement

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More than 2300 reierences on the biological responses to radio frequency and microwave radiation, published up t> April 1972, are included in this bibliography ot the world literature. Particular attention has been paid to the effects on man oi non-ionizing radiation at these frequencies. The citations are arranged alphabetically by author, and contain as ouch information as possible so as to assure effective retrieval of the original documents. Soviet and East European literature is included in detail. An outline of the effects which have been attributed to radio frequency and microwave radiation is included as Chapter 1.

The revised report (which supersedes DDC report AD#734391) is updated with the inclusion of three supplementary listings, and has incorporated many corrections and additions to the original 2100 citations.

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Foreword

It Is the hope of the author that this bibliography will provide guidance to the diffuse and conflicting literature on the biological responses to electromagnetic radiation at radio- and microwave-frequencies, with particular reference to the effects of concern to man. Such guidance is needed in the formulation and appraisal of criteria and limits of human exposure to "non-ionizing" radiation, and in the planning and conduct of future research.

The original plans were to categorize and key the literature citations to the "outline of biological and clinical effects" (Chapter 1).

This proved to be a much more difficult and time-consuming task than anticipated, and was actually completed only for about 400 papers. Thus, the letter-number combinations given in square brackets for some of the "A" through "C" citations refer to the outline. [NV] indicates the citation was "not verified".

The standard format used throughout the bibliography is: author, (date), Journal, volume , (issue): page, "title". The authors are alphabetized, and in chronological order. Multiple authors sve also alphabetically ordered according to the second, third, etc., author. Inclusive pagination is given where possible, as is the original language of the citation. Report accession and translation numbers (some of which are cited in Appendix A), and alternate sources are listed when known. The title of books is underlined. When the title of the report was not available (or not given), a short (one line) description of the paper is listed whenever possible. Reports in which the name of the author was not given are listed chronologically using the format, "title", reference, source, (date). In many cases the citation was obtained from secondary (and tertiary) sources. For this reason it was impossible to put every citation into a consistent format.

In a few cases, papers have been cited which were presented at symposia or meetings devoted to the present topic, even when the report title suggests that it does not pertain directly to the topic. This has been done to show the wide range of items considered relevant (at least at the time of the meeting, and by the organizing chairman) in past years. An example is "electroanesthesia".

A few citations of marginal and/or peripheral relationship have also been included so that the reader may judge the applicability to his individual research needs. Examples are reports dealing with the biological effects of static and alternating magnetic fields, experimental techniques using radio frequency and microwave radiation (e.g., electron spin resonance, and nuclear magnetic resonance spectroscopy), and microwave exposure limits, regulations, and standards.

References for a few limited-distribu ion government reports are available upon request.

The author welcomes information which will correct errors and omissions (both of which no doubt exist). Copies of new papers would be greatly appreciated, and would encourage updating and revising the bibliography periodically.

ACKNOWLEDGMENTS

Ihe assistance and support received during the preparation of this bibliography have been considerable, and I am happy to acknowledge my indebtedness and gratitude. Drs. John Keesey and Dennis Heffner, former and present Heads of the Biophysics Division, and Dr. Seymour Friess, Director of the Environmental Biosciences Department of the Naval Medical Research Institute, permitted me the opportunity to work on the bibliography, and offered frequent encouragement.

Acknowledgment is also due to many friends and associates for their helpful suggestions, comments, and loans and/or gifts of reports or other material, which have been invaluable in the course of the work. Mr. Glenn Helmer of the Naval Ship Engineering Center contributed an extensive collection of government reports and documents, many of which had not previously been cited in the open literature.

Special help in tracing and in the acquisition of relevant papers has been received from the librarians and staff members of the NHRI library: Mrs. Thelma Robinson, Mrs. Ernestine Gendlemsn, Mrs. Eleanor Capps, and Miss Deborah Grove. Their diligence and resourcefulness in tracing and obtaining copies of a large number of papers and reports, often in spite of incomplete and/or Inaccurate citations given in other sources, enabled me to include many relevant items in the bibliography.

Mr. Christopher Dodge of the Scientific and Technical Center, Department of the Navy, provided much of the Soviet Bloc literature, linguistic and other technical assistance, and in addition offered valuable comments and encouragement throughout the preparation of this report. Especially noteworthy were the corrections and improvements suggested by Chris following his reading of the entire manuscript.

Helpful also in locating some of the Soviet literature was Mr. Z. S. Serebrennlkov, of the Science and Technology Division, The Library of Congress.

Credit is due Mrs. Anna Woke (of this Institute) for translating many of the Genian papers; to Dr. Emilio Weiss, who translated from the Italian, and to Mrs. Edith Pugh who typed many "first drafts"; also to Mrs. Rhoda Glaser for her help in many aspects of the work.

Mrs. Fannie Epstein deserves special mention for her outstanding editorial assistance, and especially for the heroic typing, organization, and checking of the entire report.

Tl ● - atllne of Reported Biological Phenomena ('Effect*') and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation, is patterned after that given by R. Murray, et al ., in an article entitled, "flov safe are microwaves", which appeared in non-ionizing Radiation 1^(1):7-8 (1969). Some of the "effects" were listed in the report by S. F. Cleary and W. T. Ham, Jr., entitled, "Considerations in the evaluation of the biological effects on exposure to microwave radiation", (Background document. Part I, 1969, for the Task Force on Research Planning in Environmental Health, Subtask Force on Physical Factors in the Environment). The discussion and suggestions offered by Byron McLees, Edward Finch, Lewie Gersbman, and Christopher Dodge relating to the Outline are also gratefully acknowledged.

Prepaid.I tq of the bibliography was supported by the Bureau of Medicine ai.v. Surgery, Department of the Navy, under work unit MF12.524. 015-0004B.

CHAPTER 1

Reported Biological Phenomena ('Effects') and Some Clinical Manifestations Attributed to Microwave and Radio-Frequency Padiation (See Note)

A. Ueatinp of Organs* (Applications: Diathermy, P.lectrosurgery, Electrocoagulation, Electrodes5ccation, Electrotomy)

1. Elide Body (temperature regulation defects). Hyperpyrexia

2. Skin

3. Bone and Bone Marrow

4. (a) Lens of Eye (cataractous lesions - due to the avascular nature of the lens which prevents adequate heat dissipation.)

(t) Corneal damage also possil le at extremely high fre: uh.i '.c- ..

5. Ocnitalia (tubular degeneration o f testicles)

0. Brain

7. Sinuses

8. <etal Implants (burns near hip pir.s, etc.)

The effects are ;morally reversible except for 4a.

B. Changes in I'livsiologic function

1. Striated 1 uscle Contraction

2. Alteration of Diameter of Blood Vessels (increased vascular elasticity). Dilation

3. Changes in the Oxidative Processes in Tissues and Organs

4. Liver Enlargement

5. Altered Sensitivity to Drug Stimuli

6. Decreased Spermatogenesis (decreased fertility, to sterilit-)

7. Altered Sex Patio of Births (more girls!)

8. Altered Menstrual Activity

9. Altered Feta! Development

l n . increased Lactation in Nursing Mothers

11. Reduction in Diuresis (Ea + excretion, via urine output)

12. Altered Penal Function (decreased filtration l." tul ales)

13. changes in Conditioned Reflexes

14. iecreased ilectrical -eristance of Skin

15. Changes in the Structure of Skin r eccptors of tie (a) : i. f' t i ve,

and (b) Blood-Carrying Systems

16. Altered Blood flow Late

* It is also reported, that low levels of irradiation produce a cooling affect - "hypercor.ipensation",

Note: These effects are listed without comment or endorsement .-.inc-e the literature abounds with conflicting, reports. Tn some cases the Iasi*' for reporting an "effect" was a single or a nor-statistical observation which may have been drawn from a poorlv conceived (and poorlv executed) experiment.

17. Alterations in the Biocurrents (KEG?) of the Cerebral Cortex (in animals)

18. Changes in the Kate of Clearance of Tagged Ions from Tisane

19. Reversible Structural Changes in the Cerebral Cortex and the Diencephalon

20. Electrocardiographic (EKG) Changes

21. Alterations in Sensitivity to Light, Sound, and Olfactory Stimuli

22. Functional (a) and Pathological (b) Changes in the Eyes:

(a) decrease in sice of blind spot, altered color recognition, changes in intraocular pressure, lscrlnatlon, troubling cf eyelids; (b) lens opacity and coagulation, altered tissue respiration, laid altered reduction-oxidation processes

23. Myocardial Necrosis

24. Hemorrhage In Lungs, Liver, Gut, and Brain 7 At Fatal Levels

25. Generalized Degeneration of all Body Tissue 3 of Radiation

26. Loss of Anatomical Parts

27. Death

28. Dehydration

29. Altered Kate of Calcification of Certain Tissue

C. Central Nervous System Effects

1. Headaches

2. Insomnia

3. Restlessness (Awake and During Sleep)

4. Electroencephalographlc (EEG) Changes

5. Cranial Nerve Disorders

6. Pyramidal Tract Lesions

7. Conditioned Reflex Disorders

8. Vagomlnetic Action of the Heart; Synpaticomimetic Action

9. Seizures, Convulsions

D. Autonomic Nervous System Effects

1. Neuro-vegetative Disorders (e.g., alteration of heart rhythm)

2. Fatigue

3. Structural Alterations in the Synapses of the Vagus Nerve

4. Stimulation of Parasympathetic Nervous System (Bradycardia), and Inhibition of the Sympathetic Nervous System

E. Peripheral Nervous System Effects

Effects on Loans, tor Nerves

.

I-!BM S

F. Psychological Disorders ("Human Behavioral Studies") - the so-called "Psychophysiologic (and Psychosomatic) Responses"

1. Neurasthenia - (general "bad" feeling)

2. Depression

3. Impotence

4. Anxiety

5. Lack of Concentration

6. Hypochondria

7. Dizziness

8. Hallucinations

9. Sleepiness

10. Insomnia

11. Increased Irritabijity

12. Decreased Appetite

13. Loss of !ierory

14. Scalp Sensations

15. Increased Fatigability

16. Chest Pain

17. Tremor of the llanos

G. Behavioral Changes (Animal Studies)

reflexive. Operant, Avoidance, and Discrimination Behaviors

li. Blood Disorders

(V = jii vivo)

(v = Jji vitrt- '

Changes in: ~

1. Blood and Bone *!arm*

2. Phagocyt!r (polyr-orphs) and Bactericidal : unction? of (' ,v)

3. Hemolysis 'ate (increase), (a shortened lifespan of . o 1 ! '

4. Sedir.ient.ttior. i ate (increase), (due to .-bange? ;n spfi r, t ! i levels or amount of fibrinoger. (?))

5. Humber of I.rythrocytes (decrease), also number of ci tt*

C. Blood Clucose Cornentration (increase)

7. Blood Histamine Content
C. Cholesterol and I.ipids

9. Gamma (also u and S) Globulin, and Total Trotein Concentration
1C. Humber of Eosinophils

11. Albumin/Globulin Ratio (decrease)

12. Hemopoiesis (rate of formation of blood corpuscles)

13. Leukopenia (increase in number of white cells), and Leidoc-roris

14. Feticulocytosis

I. Vascular Disorders

1. Thrombosis

2. Hypertension

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J. Enzyme and Other Biochemical Changes

Changes in activity of:

1. Cholinesterase (V,v)

2. Phosphatase (v)

3. Transaminase (v)

4. Amylase (v)

5. Carboxydismutase

6. Protein Denaturation

7. Toxin, Fungus, and Virus Inactivation (at high radiation dose levels). Bacteriostatic Effect

8. Tissue Cultures Killed

9. Alteration in Rate of Cell Division

10. Increased Concentration of RUA in Lymphocytes, and Decreased Concentration in Brain,. Liver, and Spleen

11. Changes in Pyruvic Acid, Lactic Acid, and Creatinine Excretions

12. Change in Concentration of Glycogen in Liver (Hyperglycemia)

13. Alteration in Concentration of 17- Ketosteroids in Urine

K. Metabolic Disorders

1. Glycosuria (sugar in urine; related with blood sugar?)

2. Increase in Urinary Pbc-nol (derivatives? DOPA?)

3. Alteration of T.ate of Metabolic Enzymatic Processes

4. Altered Carbohydrate Metabolism

L. Gastro-Intestinal Disorders

1. Anorexia (loss of appetite)

2. Epigastric Pain

3. Constipation

4. Altered Secretion of Stomach "Digestive Juices"

M. Endocrine Gland Changes

1. Altered Pituitary Function

2. Hyperthyroidism

3. Thyroid Enlargement

4. Increased Uptake of Radioactive Iodine by Thyroid Gland

5. Altered Adrenal Cortex Activity

6. Decreased Corticosteroids in Blood

7. Decreased Glucocorticoidal Activity

8. llypogonadism (usually decreased testosterone production)

N. Histological Changes

1. Changes in Tubular Epithelium of Testicles

O. Genetic and Chromosccial Changes

1. Chromosome Aberrations (e.g., linear shortening, pseudochiasm, diploid structures, amitotic division, bridging, "sticky" chromosomes, irregularities in chromosomal envelope)

2. Mutations

3. Mongolism

4. Somatic Alterations (changes in cell not involving nucleus or chromosomes, cellular transformation)

5. Neoplastic Diseases (e.g., tumors)

P. Pearl Chain Effect (Intracellular orientation of subcellular particles, and orientation of cellular and other (non-biologic) particles)

Also, orientation of animals, birds, and fish in electromagnetic fields

Q. Miscellaneous Effects

1. Sparking between dental fillings

2. Peculiar metallic taste in mouth

3. Changes in Optical Activity of Colloidal Solutions

4. Treatment for Syphilis, Poliomyelitis, Skin Diseases

5. Loss of Hair

6. Brittleness of Hair

7. Sensations of Buzzing Vibrations, Pulsations, and Tickling About the Head and Ears

8. Copious Perspiration, Salivation, and Protrusion of Tongue

9. Changes in the Operation of Implanted Cardiac Pacemakers

10. Changes in Circadian Rhythms